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Paper-like plastic film

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The present invention relates to synthetic paper made from a coextruded, biaxially oriented plastic film having improved initial tearability and controllable tear propagation ability. The invention furthermore relates to a process for the production of the synthetic paper.

The success of biaxially oriented plastic films, in particular films comprising thermoplastic polymers and especially biaxially oriented polypropylene films, is essentially based on their excellent mechanical strength properties in combination with comparatively low weight, good barrier properties and good weldability. The polyolefin film protects the packed goods against rapid drying-out and against loss of aroma while using a very small amount of material.

What stands in the way of the consumer's need for hygienic, visually appealing, tightly sealed and robust packaging is the desire for easy and controllable opening. The latter is increasingly the subject of consumer complaints in the case of packaging comprising polyolefin films and is regarded as a disadvantage compared with paper packaging.

Uniaxially oriented films, such as, for example, tape products, exhibit distinctly low initial tear strength and/or a high tendency to split in the orientation direction, and can therefore readily be torn initially and torn further in a controlled manner in this direction. However, uniaxially oriented films are unsuitable for many application areas, inter alia owing to deficient mechanical strengths in the transverse direction. The process of biaxial orientation generates on the one hand the desired high strengths (moduli) in both dimensions; on the other hand, however, the preferential directions are also partially levelled out as a consequence of the process. This has the consequence that, in order to open film packaging (for example cookie bags), a

high force initially has to be overcome in order to tear the film. However, once the film has been damaged or partially torn, a tear propagates in an uncontrollable manner, even on application of very low tensile forces. These deficient service properties of excessively high initial tear strength and uncontrollable tear propagation behaviour reduce the acceptance of film packaging as a replacement for paper in the end consumer market, in spite of the advantages mentioned at the outset.

An attempt to solve this problem starts at the seal seam of the film packaging. Thus, for example, EP 95/P003 describes a film which, instead of a heat-sealing layer, has a peelable layer and in addition a special layer structure. This makes it possible to re-open the film packaging in a controlled manner where it was originally sealed, namely in the seam. This predetermined breaking point provided is intended to prevent tears propagating in the film in an uncontrolled manner during opening.

A further solution that has been proposed is a multilayered structure with a predetermined breaking point, i.e. with a layer which has particularly low mechanical strength. On opening, the film initially tears at this predetermined breaking point. The tear propagates only in the weak layer. This principle is implemented both in the case of coextruded films and in the case of multilayered laminates.

A further known possible solution is subsequent mechanical incorporation of a predetermined breaking point in the form of a perforation or notch.

In some cases, a tear-open tape (usually polyester) is used in order to facilitate controlled opening of the packaging. This solution is very expensive and has therefore not become established everywhere on the market.

The object of the present invention was to provide a synthetic paper which combines the advantages of a biaxially oriented plastic film with paper-like initial tear and tear propagation behaviour. No additional measures such as a tear-open tape or notch or a complex layer structure should be necessary.

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The object on which the invention is based is achieved by a biaxially oriented polymer film having at least one layer, where this layer is a fibre-containing layer which is built up from a thermoplastic polymer and contains natural fibres, polymer fibres or mineral fibres.

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Mineral fibres of asbestos or glass fibres, in particular long glass fibres, are excepted. The former are ruled out owing to their potential risk (carcinogeneity, respirability) for employees of film manufacturers and processors, the latter are disadvantageous owing to their high abrasiveness and the consequent wear of machine parts.

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The paper-like film can be made translucent to transparent or in the form of an opaque film, depending on the proposed application. For the purposes of the present invention, "opaque film" means a non-transparent film whose light transmission (ASTM-D 1003-77) is at most 70%, preferably at most 50%.

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At least one layer of the films according to the invention contains mineral fibres, such as wollastonite or polymer or natural fibres. This fibre-containing layer of the film, which contributes to the paper-like tear behaviour, is built up from thermoplastic polymers.

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Possible thermoplastic polymers for the polymer matrix of the fibre-containing layer are polyimides, polyamides, polyesters, PVC or polyolefins made from olefinic monomers having from 2 to 8 carbon atoms. Particularly suitable are polyamides and polyolefins, of which propylene polymers, ethylene polymers,

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butylene polymers, cycloolefin polymers or copolymers comprising propylene, ethylene and butylene units or cycloolefins are preferred. In general, the fibre-containing layer comprises at least 50% by weight, preferably from 70 to 99% by weight, in particular from 90 to 98% by weight, of the thermoplastic polymer, in each case based on the weight of the layer.

Preferred polyolefins are propylene polymers. These propylene polymers comprise from 90 to 100% by weight, preferably from 95 to 100% by weight, in particular from 98 to 100% by weight, of propylene and have a melting point of 120°C or above, preferably from 130 to 170°C, and generally have a melt flow index of from 0.5 g/10 min to 15 g/10 min, preferably from 2 g/10 min to 10 g/10 min, at 230°C and a force of 21.6 N (DIN 53 735). Isotactic propylene homopolymer having an atactic content of 15% by weight or less, copolymers of ethylene and propylene having an ethylene content of 10% by weight or less, copolymers of propylene with C₄-C₈-olefins having an olefin content of 10% by weight or less, terpolymers of propylene, ethylene and butylene having an ethylene content of 10% by weight or less and having a butylene content of 15% by weight or less are preferred propylene polymers for the core layer, particular preference being given to isotactic propylene homopolymer. The stated percentages by weight are based on the respective polymer.

Also suitable is a mixture of the said propylene homopolymers and/or copolymers and/or terpolymers and other polyolefins, in particular made from monomers having from 2 to 6 carbon atoms, where the mixture comprises at least 50% by weight, in particular at least 75% by weight, of propylene polymer. Suitable other polyolefins in the polymer mixture are polyethylenes, in particular HDPE, LDPE, VLDPE and LLDPE, where the proportion of these polyolefins does not exceed 15% by weight, based on the polymer mixture, in each case.

Besides the thermoplastic polymer, the fibre-containing layer of the film contains fibres in an amount of at most 50% by weight, preferably from 0.5 to 10% by weight, in particular from 1 to 5% by weight, based on the weight of the fibre-containing layer.

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Various materials are basically suitable for the fibres. Suitable fibres are those made from thermoplastic polymers, from crosslinked thermoplastic polymers, amorphous polymers, semi-crystalline polymers, stabilised natural fibres or crystalline mineral fibres.

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Fibres made from thermoplastic polymers, such as polyolefins, polyethylenes, polypropylenes, cycloolefin polymers, copolymers, polyesters, polyamides, polyimides or polyaramids, are suitable. It is also possible to use fibres made from crosslinked thermoplastic polymers, radiation-crosslinked or chemically crosslinked thermoplastic polymers containing correspondingly reactive groups. It is also possible to employ stabilised natural fibres, such as cotton fibres or cellulose fibres or crystalline mineral fibres, such as, for example, wollastonite or calcium silicates, for example Tremin 939 from Quarzwerke GmbH, Frechen, FRG, and other minerals having a corresponding morphology.

For the purposes of the present invention, the term "mineral fibres" does not include glass fibres. As part of the investigations for the present invention, it was found that glass fibres are unsuitable for biaxially oriented films. Amongst other things, severe damage to dies and rolls of the BOPP plant occur on use of thermoplastic polymers filled with glass fibres.

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The fibre dimensions, in particular the lengths and diameters, depend on the specific area of application of the film and also on the film thickness. The median values of fibre diameters are advantageously in the range from 1.5 to 50 μm , preferably from 3 to 20 μm , and the fibre length is in the range from 10

to 250 μm , preferably from 20 to 50 μm , and the fibre L/D ratio is in the range from 5 to 50, preferably from 10 to 30.

In a further embodiment, the fibres may be provided with a suitable coating. In particular, preferred coatings are those which improve the rheology and compatibility of the fibres with the polymer matrix. The coating may, if desired, contain a stabiliser, in particular in the case of polymer fibres. Preference is given to organic coatings for control of the compatibility with the polymer matrix.

Of the fibres made from thermoplastic polymers, preference is given for particular embodiments to matted fibres. These contain matting agents, preferably titanium dioxide, which is added to the spin composition during fibre production, in order to reduce the natural gloss of the polymer fibres. This gives TiO_2 -pigmented fibres, whose use in the fibre-containing layer of the film according to the invention is particularly preferred. These embodiments are distinguished by increased whiteness and a particularly paper-like appearance.

The fibres must be substantially stable to the processing process, i.e. during extrusion and subsequent orientation. In particular, the fibre structure must be substantially retained during production of the film. For this purpose, the material, in particular in the case of fibres made from thermoplastic polymers, should have a sufficiently high melting or softening point so that the fibre retains its shape and does not melt at the processing temperature of the respective matrix polymer.

Surprisingly, the fibres effect a change in the tear behaviour in the biaxially oriented film. The tear behaviour of the film becomes much more similar to the tear behaviour of paper. This effect is particularly surprising against the background of expert knowledge on fibre-reinforced plastics. It is known to add

fibres to extrudates made from thermoplastics in the area of injection moulding in order to produce fibre-reinforced plastics. This improves the mechanical properties of the extrudates, enabling the parts to be employed, in particular, in areas where particularly high mechanical loads occur. On application of this knowledge to biaxially oriented films, an increase in the mechanical strength would have been expected. However, such an increase in the strength or rigidity of the film was not noted. By contrast, easier initial tearability was observed, i.e. lower mechanical strength was noted.

10 This effect is particularly pronounced if the fibres are employed in an interlayer or in the base layer of the film. Fibres are less advantageous in a thin top layer of heat-sealable polymers. On the one hand, the initial tear force is only reduced to an insignificant extent. On the other hand, the fibres as additives to the top layers may have an adverse effect on the heat-sealing properties and the printability of the film.

Surprisingly, it has additionally been observed that the texture of the film surfaces and – associated therewith – the optical appearance and haptic properties of the film become paper-like. The paper-like property profile is also evident in the sound impression made on initial tearing. In addition, particular embodiments exhibit increased water vapour permeability (breathability).

If desired, the fibre-containing layer may additionally comprise pigments and/or vacuole-initiating particles in conventional amounts in each case.

25 For the purposes of the present invention, pigments are incompatible particles which essentially do not result in vacuole formation on stretching of the film and generally have a mean particle diameter in the range from 0.01 to a maximum of 1 μm , preferably from 0.01 to 0.7 μm , in particular from 0.01 to 0.4 μm . The layer generally comprises pigments in an amount of from 1 to 15%

by weight, preferably from 2 to 10% by weight, in each case based on the weight of the layer.

Conventional pigments are materials such as, for example, aluminium oxide, aluminium sulphate, barium sulphate, calcium carbonate, magnesium carbonate, silicates such as aluminium silicate (kaolin clay) and magnesium silicate (talc), silicon dioxide and titanium dioxide, of which white pigments, such as calcium carbonate, silicon dioxide, titanium dioxide and barium sulphate, are preferably employed.

If desired, the layer may additionally comprise vacuole-initiating fillers, generally in an amount of 1-15% by weight, preferably 2-10% by weight, in particular 1-5% by weight.

For the purposes of the present invention, "vacuole-initiating fillers" are solid particles which are incompatible with the polymer matrix and result in the formation of vacuole-like cavities on stretching of the films, where the size, nature and number of the vacuoles are dependent on the size of the solid particles and the stretching conditions, such as stretching ratio and stretching temperature. The vacuoles reduce the density, give the films a characteristic mother-of-pearl-like, opaque appearance caused by light scattering at the "vacuole/ polymer matrix" interfaces. In general, the vacuole-initiating fillers have a minimum size of 1 μm . In general, the mean particle diameter of the particles is from 1 to 6 μm , preferably from 1,5 bis 3 μm .

The fibre-containing layer of the film according to the invention may be the only layer of a single-layered embodiment of the paper-like plastic film. The fibre-containing layer may also be the base layer of a multilayered embodiment of the film. The fibre-containing layer is preferably an interlayer applied to the base layer. Correspondingly, multilayered embodiments of the paper-like film

additionally have a base layer or an interlayer or a top layer in addition to the fibre-containing layer.

These additional layers, which are generally fibre-free, are generally built up from thermoplastic polymers. They comprise at least 70% by weight, preferably from 75 to 100% by weight, in particular from 90 to 98% by weight, of a thermoplastic polymer. Suitable thermoplastic polymers for these additional layers are basically the same polymers as described above for the fibre-containing layer.

- 10 Suitable for the top layers are copolymers of ethylene and propylene or ethylene and butylene or propylene and butylene or
- 15 ethylene and another olefin having 5 to 10 carbon atoms or propylene and another olefin having 5 to 10 carbon atoms or a terpolymer of ethylene and propylene and butylene or ethylene and propylene and another olefin having 5 to 10 carbon atoms or
- 20 a mixture or blend of two or more of the said homopolymers, copolymers and terpolymers.

- Of these, particular preference is given to random ethylene-propylene copolymers having
- 25 an ethylene content of from 2 to 10% by weight, preferably from 5 to 8% by weight, or random propylene-1-butylene copolymers having a butylene content of from 4 to 25% by weight, preferably from 10 to 20% by weight,
- 30 in each case based on the total weight of the copolymer, or

random ethylene-propylene-1-butylene terpolymers having
an ethylene content of from 1 to 10% by weight, preferably from 2 to 6% by
weight, and
a 1-butylene content of from 3 to 20% by weight, preferably from 8 to 10% by
5 weight,
in each case based on the total weight of the terpolymer, or
a blend of an ethylene-propylene-1-butylene terpolymer and a propylene-
1-butylene copolymer
having an ethylene content of from 0.1 to 7% by weight
10 and a propylene content of from 50 to 90% by weight
and a 1-butylene content of from 10 to 40% by weight,
in each case based on the total weight of the polymer blend.

The copolymers or terpolymers described above generally have a melt flow
15 index of from 1.5 to 30 g/10 min, preferably from 3 to 15 g/10 min. The melting
point is in the range from 120 to 140°C. The above-described blend of
copolymers and terpolymers has a melt flow index of from 5 to 9 g/10 min and a
melting point of from 120 to 150°C. All the melt flow indices indicated above
are measured at 230°C and a force of 21.6 N (DIN 53 735). Layers of
20 copolymers and/or terpolymers preferably form the top layers of heat-sealable
embodiments of the film.

The total thickness of the film can vary within broad limits and depends on the
intended application. The preferred embodiments of the paper-like film
25 according to the invention have total thicknesses of from 5 to 250 µm;
preferably from 10 to 100 µm, in particular from 20 to 60 µm.

The thickness of the fibre-containing layer is selected independently of other
layers and is preferably in the range from 1 to 250 µm, in particular from 3 to
30 50 µm.

The apparent density of the film is in the range from 0.3 to 1.5 g/cm³ (measurement method in accordance with DIN).

- 5 For the purposes of the present invention, the base layer is the layer that makes up more than 50% of the total thickness of the film. Its thickness is given by the difference between the total thickness and the thickness of the top layer(s) and interlayer(s) applied and can therefore vary within broad limits analogously to the total thickness. Top layers form the outermost layer of the
10 film.

- In order to improve certain properties of the polypropylene film according to the invention still further, both the base layer and the interlayer(s) and the top layer(s) may comprise additives in an effective amount in each case, preferably
15 hydrocarbon resin and/or antistatics and/or antiblocking agents and/or lubricants and/or stabilisers and/or neutralising agents which are compatible with the polymers of the core layer and the top layer(s), with the exception of the antiblocking agents, which are generally incompatible.

- 20 The invention furthermore relates to a process for the production of the multi-layered film according to the invention by the extrusion process, which is known per se. The conditions during the production process depend on the respective polymer matrix which forms the principal constituent of the film. The process for the production of a polypropylene film is described in detail below
25 as an example.

In this process, the melts corresponding to the individual layers of the film are coextruded through a slot die, the film obtained in this way is taken off on one or more roll(s) for solidification, the film is subsequently biaxially stretched and

heat-set and, if desired, correspondingly surface-treated on the surface layer provided for the surface treatment.

5 Biaxial stretching (orientation) is preferred and can be carried out simultaneously or successively, with successive biaxial stretching, in which stretching is firstly carried out longitudinally (in the machine direction) and then transversely (perpendicular to the machine direction), being particularly favourable.

10 Firstly, as usual in the coextrusion process, the polymer or polymer mixture of the individual layers is compressed and liquefied in an extruder, it being possible for the fibres and any additives added to be already present in the polymer. The melts are then pressed simultaneously through a slot die (flat-film die), and the extruded single- or multilayered film is taken off on one or more
15 take-off rolls, during which it cools and solidifies.

The film obtained in this way is preferably then stretched longitudinally and transversely to the extrusion direction, which results in orientation of the molecule chains. The stretching in the longitudinal direction is preferably
20 carried out at from 3:1 to 7:1 and the stretching in the transverse direction is preferably carried out at from 5:1 to 12:1. The longitudinal stretching is advantageously carried out with the aid of two rolls running at different speeds corresponding to the target stretching ratio, and the transverse stretching is carried out with the aid of a corresponding tenter frame. For biaxial stretching,
25 stretching can in principle also be carried out simultaneously in the longitudinal/transverse directions. These simultaneous stretching processes are known per se in the prior art.

The biaxial stretching of the film is followed by its heat setting (heat treatment),
30 in which the film is held at a temperature of from 110 to 150°C for about 0.5 to

10 s. The film is subsequently wound up in a conventional manner using a wind-up device.

It has proven particularly favourable to keep the take-off roll or rolls by means of which the extruded film is also cooled and solidified, at a temperature of from 5 10 to 90°C, preferably from 20 to 60°C.

In addition, the longitudinal stretching is advantageously carried out at a temperature of less than 140°C, preferably in the range from 125 to 135°C, and 10 the transverse stretching at a temperature of above 140°C, preferably at from 145 to 160°C.

If desired, as mentioned above, one or both surface(s) of the film can be corona- or flame-treated by one of the known methods after the biaxial 15 stretching.

If desired, the film can be coated, melt-coated, varnished or laminated by suitable coating processes in subsequent processing steps in order to impart further advantageous properties.

20 The plastic film according to the invention is distinguished by relatively easy initial tearability. The force that has to be applied to initiate a tear at the film edge is significantly reduced. Undesired distension at the edge does not occur on initial tearing, so that the film withstands the initial tearing. Initial tearing of 25 the film is significantly easier and the tears can then be propagated in a more controlled manner. In addition, it also exhibits paper-like character with respect to appearance, haptic properties and water vapour permeability.

The following measurement methods were used in order to characterise the 30 fibres and the films:

The following method was used for characterisation of the median values of fibre length/diameter and L/D ratio:

- 5 A sufficiently thin coat of the fibre material to be investigated is observed under a microscope. The magnification should be selected in a suitable way so that a representative ensemble can be investigated. With the aid of suitable software support, the individual fibres can be measured with respect to their length, their diameter and thus also their L/D ratio. Through definition of suitable sub-
10 ensembles, discrete distributions of fibre length and diameter can be set up, enabling evaluation of the median values.

Weight per unit area:

The weight per unit area is determined in accordance with DIN EN ISO 536.

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Modulus of elasticity:

The moduli of elasticity in the longitudinal and transverse directions are determined in accordance with DIN EN ISO 527-1 and 527-3.

20 Tear propagation strength:

The tear propagation strength in the longitudinal and transverse directions is determined in accordance with ASTM D1938-85.

Initial tear resistance:

- 25 The initial tear resistance in the longitudinal direction is determined in accordance with ASTM D1004-66.

Coefficient of dynamic friction i/o

- 30 The coefficient of friction at the limit of sliding of the inside of the film (i) against its outside (o) was determined in accordance with DIN 53375.

Water vapour permeability

The water vapour permeability was determined in accordance with DIN 53122 Part 2 at 37.8°C and 90% relative humidity.

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All fibre types employed are listed below with their characteristic properties.

Table (fibre characterisation)

Fibre type	Nature	Weight average length [µm]	Weight average diameter [µm]	L/D ratio
A	Cellulose	197	20	10
B	Cellulose	18	15	1
C	Cotton	390	16	23
D	Cotton	510	17	29
E	Nylon 6.6	620	20	30
F	Wollastonite	66	8	8
G	Wollastonite	50	7	7

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The invention is now explained by the following examples.

Example 1: Fibres in the interlayers of a five-layered film having a transparent base layer

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A transparent five-layered film was produced via the corresponding process steps, i.e. after coextrusion, the film was taken off and cooled over a first take-off roll and a further triple roll, subsequently stretched in the longitudinal direction, stretched in the transverse direction, set and corona-treated, with the

20 following conditions being selected:

Extrusion:	extrusion temperature 250°C
Longitudinal stretching:	stretching roll T = 120°C
Longitudinal stretching by the	factor 4.5
5 Transverse stretching:	heating zone T = 170°C
	stretching zone T = 165°C
Transverse stretching by the	factor 8
Setting:	temperature T = 155°C
Corona treatment:	voltage: 10,000 V
10	frequency: 10,000 Hz

The base layer of the film essentially comprised a propylene homopolymer. In the interlayers, either propylene homopolymer or a propylene-ethylene copolymer was employed. The interlayers contained various fibres in an amount of up to 30% by weight. The top-layer material employed on both sides was a heat-sealable copolymer. All layers comprised conventional stabilisers and neutralisers.

The multilayered film produced in this way had a surface tension of from 40 to 41 mN/m (top side) directly after production. The films had a thickness of about 35 – 43 µm. The thickness of the top layers was in each case about 0.7 µm; the thickness of the two interlayers was in each case about 3 µm. The films exhibited a paper-like appearance with all fibre types used. The initial tearability was significantly reduced. The films sounded like paper on initial tearing and further tearing. Their coefficient of friction was reduced.

Comparative Example 1

In comparison with Example 1, a film having the same layer structure as described in Example 1 was produced. The only difference was that no fibres were added to the interlayers.

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Table 1

Film properties of the films in accordance with Example 1 and Comparative Example 1

Fibre type used Fibre concentration [%]	D 2.5	C 2.5	B 2.5	A 2.5	Comp. Example No fibres
Weight per unit area [g/m ²]	27.6	27.9	33.2	30.5	34.3
Mod. of elasticity, longitudinal [N/mm ²]	1700	1700	1900	1700	1900
Mod. of elasticity, transverse [N/mm ²]	4600	4900	5000	4600	5400
Initial tear strength [N]	6.9	7.2	8.0	7.9	9.6
Tear prop. strength, longitudinal [mN]	96	124	156	144	164
Tear prop. strength, transverse [mN]	44	32	44	80	60
Dynamic coeff. of friction i/o	0.35	0.4	0.35	0.3	0.5

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Example 2: Fibres in the core layer of a transparent five-layered film

A film was produced as described in Example 1. In contrast to Example 1, the fibres were now incorporated into the base layer of the film. The interlayers remained fibre-free. Via the corresponding process steps after coextrusion, the extruded, transparent five-layered film was taken off and cooled over a first take-off roll and a further triple roll, subsequently stretched in the longitudinal direction, stretched in the transverse direction, set and corona treated, with the following conditions being selected:

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Extrusion:

extrusion temperature 250°C

- Longitudinal stretching: stretching roll T = 114°C
 Longitudinal stretching by the factor 4.5
 Transverse stretching: heating zone T = 172°C
 stretching zone T = 160°C
 5 Transverse stretching by the factor 8
 Setting: temperature T = 150°C
 Corona treatment: voltage: 10,000 V
 frequency: 10,000 Hz

- 10 The multilayered film produced in this way had a surface tension of from 40 to 41 mN/m (top side) directly after production. The films had a thickness of about 38 – 42 µm. The thickness of the top layers was in each case about 0.7 µm; the thickness of the two interlayers was in each case about 3 µm. Irrespective of the fibre type used, the films of Example 2 exhibit a paper-like appearance.
 15 The initial tearability is significantly reduced. The film sounds like paper on initial tearing and further tearing. Its coefficient of friction is reduced.

Comparative Example 2

- 20 A film was produced as described in Example 2. In contrast to Example 2, the film contained no fibres in the base layer.

Table 2

Film properties of Example 2 and Comparative Example 2

Fibre type used Fibre concentration [%]	F 7.5	F 5.0	Comp. Example No fibres
Weight per unit area [g/m ²]	38.1	36.4	34.6
Mod. of elasticity, longitudinal [N/mm ²]	1700	1800	2000
Mod. of elasticity, transverse [N/mm ²]	2800	3000	3500

Initial tear strength/longitudinal [N]	7.7	8.1	9.4
Tear prop. strength, longitudinal [mN]	88	128	124
Tear prop. strength, transverse [mN]	40	28	60
Dynamic coeff. of friction i/o	0.30	0.32	0.45

Example 3: Fibres in the interlayers of a five-layered film having an opaque core layer

- 5 A film was produced as described in Example 1. In contrast to Example 1, the base layer additionally comprised calcium carbonate and titanium dioxide. Via the corresponding process steps after coextrusion, the extruded, opaque five-layered film was taken off and cooled over a first take-off roll and a further triple roll, subsequently stretched in the longitudinal direction, stretched in the transverse direction, set and corona treated, with the following conditions being selected:

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|-----------------------------------|-----------------------------|
| Extrusion: | extrusion temperature 240°C |
| Longitudinal stretching: | stretching roll T = 114°C |
| 15 Longitudinal stretching by the | factor 4.5 |
| Transverse stretching: | heating zone T = 172°C |
| | stretching zone T = 160°C |
| Transverse stretching by the | factor 8 |
| Setting: | temperature T = 150°C |
| 20 Corona treatment: | voltage: 10,000 V |
| | frequency: 10,000 Hz |

- 25 The multilayered film produced in this way had a surface tension of from 40 to 41 mN/m (top side) directly after production. The films had a thickness of about 32 – 44 µm. The thickness of the top layers was in each case about 0.7 µm; the thickness of the two interlayers was in each case about 3 µm. Irrespective of the fibre type used, the films of the example exhibit a similar appearance. The

initial tearability is significantly reduced. The film sounds like paper on initial tearing and further tearing. Its coefficient of friction is reduced. The film having an increased fibre concentration in the interlayer (type F; 15%) exhibits a significantly increased water vapour permeability (about 50%).

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Comparative Example 3

A film was produced as described in Example 3. In contrast to Example 3, the interlayers contained no fibres.

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Table 3 (film properties)

Fibre type used Fibre concentration [%]	F 15.0	D 2.5	C 2.5	B 2.5	Comp. Example No fibres
Weight per unit area [g/m ²]	29.7	20.4	26.4	26.3	30.8
Mod. of elasticity, longitudinal [N/mm ²]	1500	1100	1200	1300	1600
Mod. of elasticity, transverse [N/mm ²]	2400	2200	2300	2300	2900
Initial tear strength [N]	5.2	6.8	6.4	6.7	8.5
Tear prop. strength, longitudinal [mN]	82	56	84	68	94
Tear prop. strength, transverse [mN]	63	52	36	40	55
Dynamic coeff. of friction i/o	0.25	0.35	0.3	0.4	0.55
WVP (37.8°C and 90% r.h.)	7.8	-	-	-	6.8

Example 4: Fibres in the core layer of a five-layered film having an opaque core layer

- 15 A film was produced as described in Example 2. In contrast to Example 2, the film now additionally comprised calcium carbonate and titanium dioxide in its base layer.

20 Via the corresponding process steps after coextrusion, the extruded, opaque five-layered film was taken off and cooled over a first take-off roll and a further

triple roll, subsequently stretched in the longitudinal direction, stretched in the transverse direction, set and corona treated, with the following conditions being selected:

- | | | |
|----|--------------------------------|-----------------------------|
| 5 | Extrusion: | extrusion temperature 245°C |
| | Longitudinal stretching: | stretching roll T = 114°C |
| | Longitudinal stretching by the | factor 4.5 |
| | Transverse stretching: | heating zone T = 170°C |
| | | stretching zone T = 160°C |
| 10 | Transverse stretching by the | factor 8 |
| | Setting: | temperature T = 150°C |
| | Corona treatment: | voltage: 10,000 V |
| | | frequency: 10,000 Hz |

- 15 The multilayered film produced in this way had a surface tension of from 40 to 41 mN/m (top side) directly after production. The films had a thickness of about 40 – 52 µm. The thickness of the top layers was in each case about 0.7 µm; the thickness of the two interlayers was in each case about 3 µm. Irrespective of the fibre type used, the films of the example exhibit a similar appearance. The
- 20 initial tearability is significantly reduced. The film sounds like paper on initial tearing and further tearing.

Comparative Example 4

- 25 A film was produced as described in Example 4. In contrast to Example 4, the base layer now contained no fibres.

Table 4 (film properties)

Fibre type used Fibre concentration [%]	E 1.5	Comp. Example No fibres
Weight per unit area [g/m ²]	30.4	31.1
Mod. of elasticity, longitudinal [N/mm ²]	1156	1700
Mod. of elasticity, transverse [N/mm ²]	2600	3000
Initial tear strength [N]	7.7	8.6
Tear prop. strength, longitudinal [mN]	92	76
Tear prop. strength, transverse [mN]	68	52

- 5 Example 5: Fibres in the core layer and interlayers of a five-layered film having an opaque core layer

10 A film was produced as described in Example 4. In contrast to Example 4, the film additionally contained fibres in the interlayer in an amount of up to 30% by weight, i.e. both the base layer and the interlayer contained fibres in this example.

15 Via the corresponding process steps after coextrusion, the extruded, opaque five-layered film was taken off and cooled over a first take-off roll and a further triple roll, subsequently stretched in the longitudinal direction, stretched in the transverse direction, set and corona treated, with the following conditions being selected:

Extrusion: extrusion temperature 245°C
 Longitudinal stretching: stretching roll T = 114°C
 Longitudinal stretching by the factor 4.5
 Transverse stretching: heating zone T = 170°C
 stretching zone T = 160°C
 5 Transverse stretching by the factor 8
 Setting: temperature T = 150°C
 Corona treatment: voltage: 10,000 V
 frequency: 10,000 Hz

10

The multilayered film produced in this way had a surface tension of from 40 to 41 mN/m (top side) directly after production. The films had a thickness of about 40 – 48 µm. The thickness of the top layers was in each case about 0.7 µm; the thickness of the two interlayers was in each case about 3 µm. Irrespective of the fibre type used, the films of the example exhibit a similar appearance. The 15 initial tearability is significantly reduced. The film sounds like paper during initial tearing and further tearing. Its coefficient of friction is reduced.

Table 5 (film properties)

Fibre type used	F	F	G	G	Comp. Example
Fibre concentration [%] in interlayer	7.5	7.5	7.5	7.5	No fibres
Fibre concentration [%] in core layer	5.0	2.5	5.0	2.5	
Weight per unit area [g/m ²]	28.8	29.0	32.9	31.6	29.4
Mod. of elasticity, longitudinal [N/mm ²]	1100	1300	1200	1400	1500
Mod. of elasticity, transverse [N/mm ²]	1600	2000	1700	2100	2600
Initial tear strength [N]	6.3	6.7	5.9	7.0	8.5
Tear prop. strength, longitudinal [mN]	124	116	124	112	100
Tear prop. strength, transverse [mN]	232	156	60	64	58
WVP (37.8°C and 90% r.h.)	7.3	7.0	7.5	6.8	6.5